Space Weather Technical Forecast

Issued on Saturday, 30 December 2023 at 12:24 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of M-flares. Slight chance G1-Minor storms from coronal hole fast wind onset day 3 (01 Jan).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low with peak flare C6.6 at 29/2017 UTC from AR3530 near the west limb, and further occasional small C-class flares. This region is now close to the horizon, so difficult to assess. There are five sunspot regions on the disc, with the main development occurring with AR3534 in the southeast. This saw the formation of small asymmetric penumbra on both leader and trailer spots, along with small growth of intermediate spots, and was the source of small C-class flaring. The other regions on the disc remained small and stable, with AR3533 showing sign of decay.

There were no Earth-directed CMEs observed, however a large filament eruption occurred off the southeast disc, with imagery for analysis currently not available. Given the location of the eruption, an Earth-directed component is not expected. There are further notable filaments on the Earth-side of the Sun, including a large mobile filament in the northwest, however these are mainly rotating towards the western horizon with a lowering chance of any Earth-directed eruption.

Solar Wind / Geomagnetic Activity: Weak CME affects gave way to more typical slow wind conditions through the period. Mainly background speeds were observed, generally between 350-400 km/s but with a brief spike at 29/2146 UTC to slightly elevated levels near 450 km/s before quickly easing back to background. Density was around or below average. Interplanetary Magnetic Field (IMF), Bt, was weak to moderate, with a couple of small enhancements, initially to 10nT before easing a little, but then also at 29/2230 UTC to 12nT, before again easing to be mainly weak at 5-8nT from 29/0600 UTC. The north-south component, Bz, was mainly positive (northward) peaking +9nT, but with brief rotations to negative (southward) reaching a minimum of -5nT. Phi angle was mainly negative (towards the Sun), with brief period of positive (away from the Sun). Geomagnetic activity remained Quiet (Kp1-2).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux was at background. GOES16 high energy (greater than 2MeV) electron flux ranged diurnally between background and moderate levels. The 24-hour fluence was below Active throughout and has been slowly declining. The 30/0000 UTC observation was 6.88e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low activity is expected, but with an increasing chance of rising to Moderate with isolated M-flares possible, given any further development of the regions on the Earth-facing disc, or from the expected return of ex-AR3514 later in the period.

Solar Wind / Geomagnetic Activity: There are no Earth-directed CMEs. Slow wind conditions are expected until the arrival of the fast wind of CH86 on day 3 (01 Jan). Elevated winds are forecast, around 500-600km/s, and likely persisting day 4 (02 Jan). Mainly Quiet geomagnetic activity at first, becoming Unsettled day 3 with a chance of Active intervals and a slight chance of an isolated G1 Minor Storm interval from the fast wind onset. Activity easing to Quiet with a

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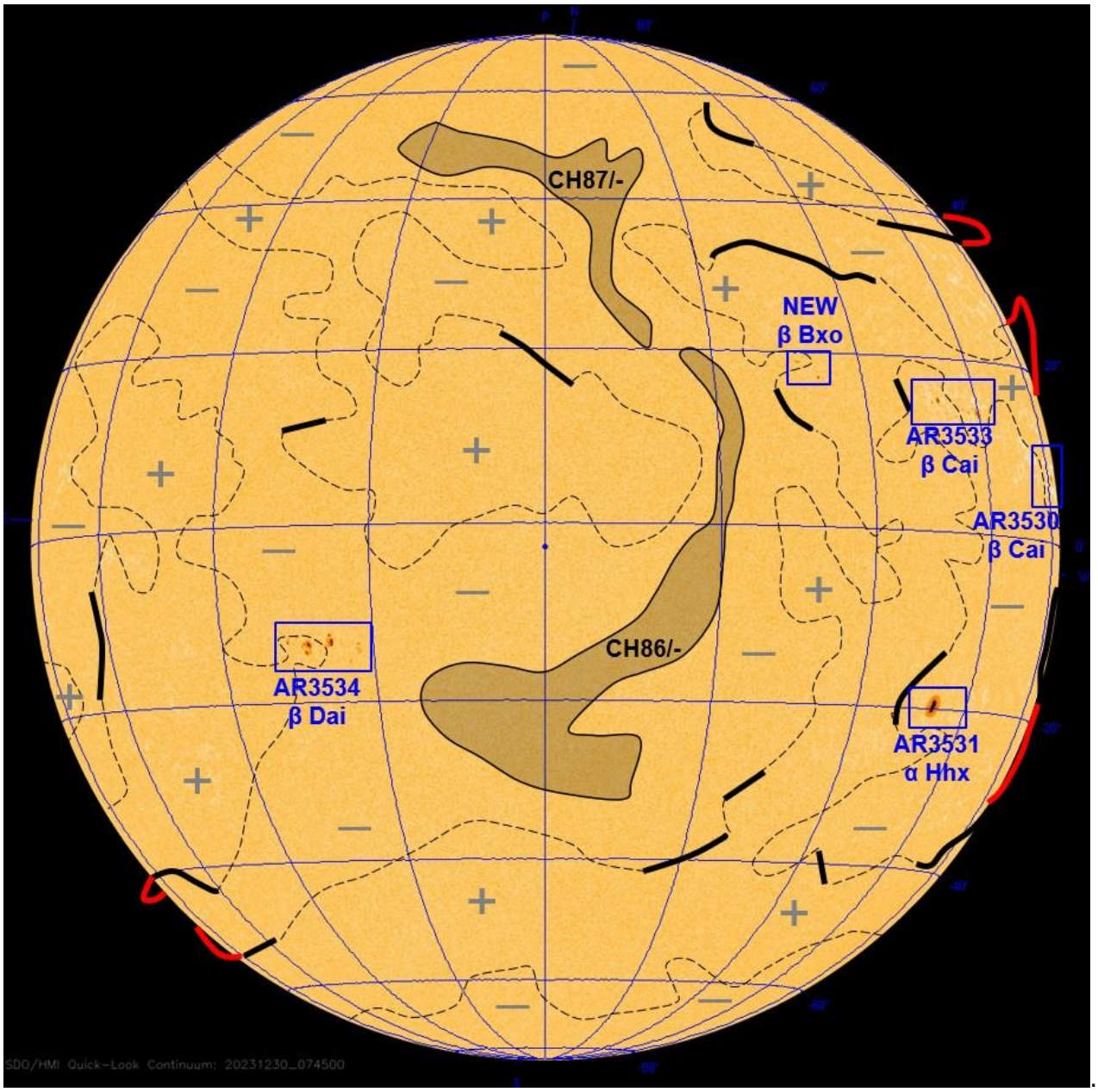
chance of Unsettled intervals day 4.

Energetic Particles / Solar Radiation: GOES16 high energy proton flux is expected to persist at background. GOES16 high energy electron flux is likely to remain at moderate or background levels initially, before dropping out with any fast wind onset. Flux potentially rising to Moderate with a chance of reaching High at diurnal peak on day 4 (02 Jan). The associated 24 hour fluence is expected to remain below Active through the period.

Figure 1. Solar Analysis Valid 30/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are no Earth-directed CMEs.

Slow wind conditions day 1 and likely day 2 (30-31 Dec), with background speeds, are expected to become elevated on day 3 (01 Jan) due to the onset of fast winds from CH86/-. This is a relatively narrower feature compared with last rotation, at least with its equatorial section, and only result in Unsettled geomagnetic conditions with solar wind speeds 500-600km/s. Similar speeds are expected on this occasion, in line with MOSWOC Enlil, however, as a persistent feature there remains the chance for Active intervals and slight chance of G1/Minor Storms. Elevated winds are likely to persist day 3 and day 4 (01-02 Jane),

Overall mainly Quiet geomagnetic activity is expected day 1-2 (30-31 Dec) becoming Unsettled with a chance of Active intervals day 3 (01 Jan), before easing to Quiet with Unsettled intervals day 4 (02 Jan).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	5	20	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2a: SDO aia-211 of previous rotation (left) and current rotation (right)

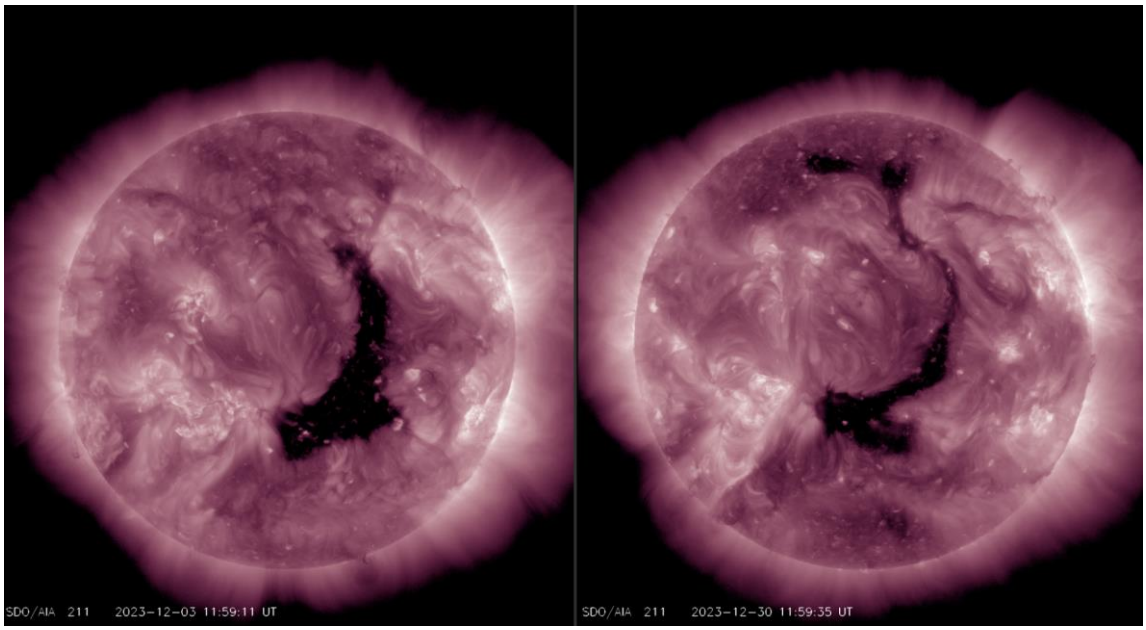

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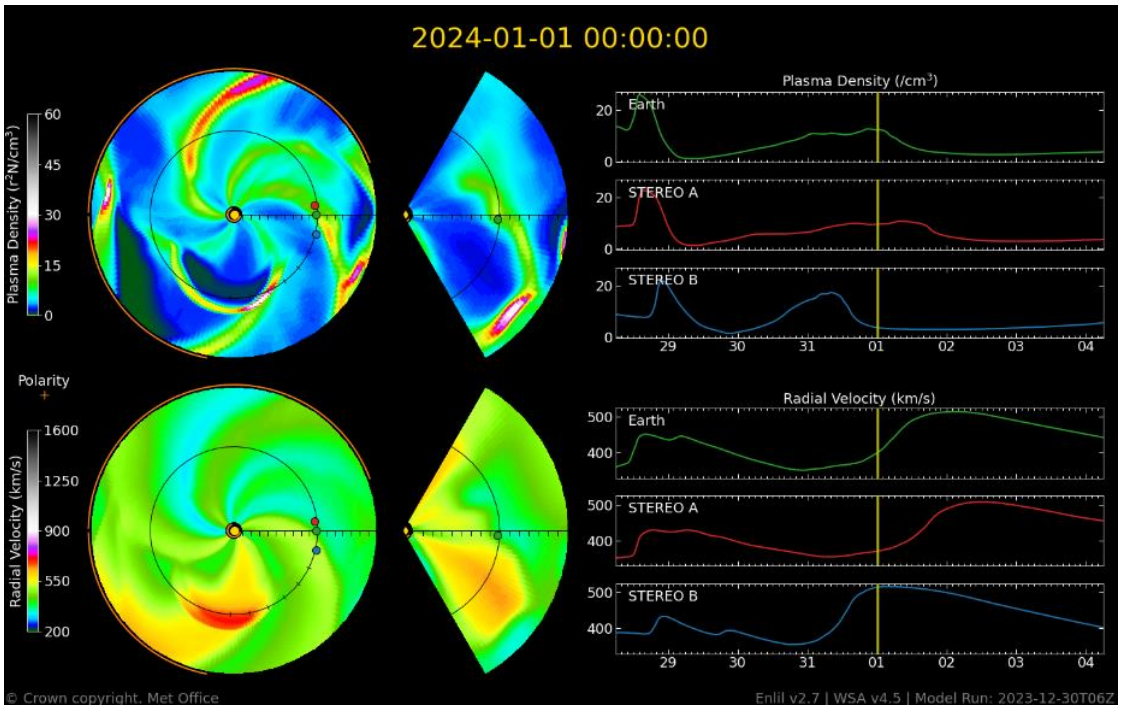
Figure 2b: Enlil showing expected CH86 enhancement on 01 Jan.



Radio Blackouts - X-Ray Flares:

Low activity is expected, but with an increasing chance of rising to Moderate with isolated M-flares possible, given any further development of the regions on the Earth-facing disc, or from the expected return of ex-AR3514 later in the period.

There are five sunspot regions on the visible disc, four of which are numbered. The most notable is developing AR3534, with ongoing flux emergence, although the magnetic configuration of the spot remains simple, aligned east-west with no mixing of polarities. The other regions remain smaller and simpler, with AR3533 now showing some signs of decay.

Far-sided products, including those from stanford.edu and from H-alpha imagery from NISP, both show the persistence of a strong feature that is expected to move onto the western limb on day 3 (1 Jan). This is likely associated with ex-A3514 which produced an X2.8 flare on 14 Dec, before moving onto the far-side. This region was visible to the Mars Perseverance rover on 22 Dec, however it remains uncertain how much of this region has persisted its transit across the disc, or how complex it remains. However this does bring an increased likelihood of flare activity by the end of the period.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	25	30	40	40
Very Active	R3 to R5 X Class	No	1	1	1	1

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Figure 3a: GOES-16/18 X-ray Flux

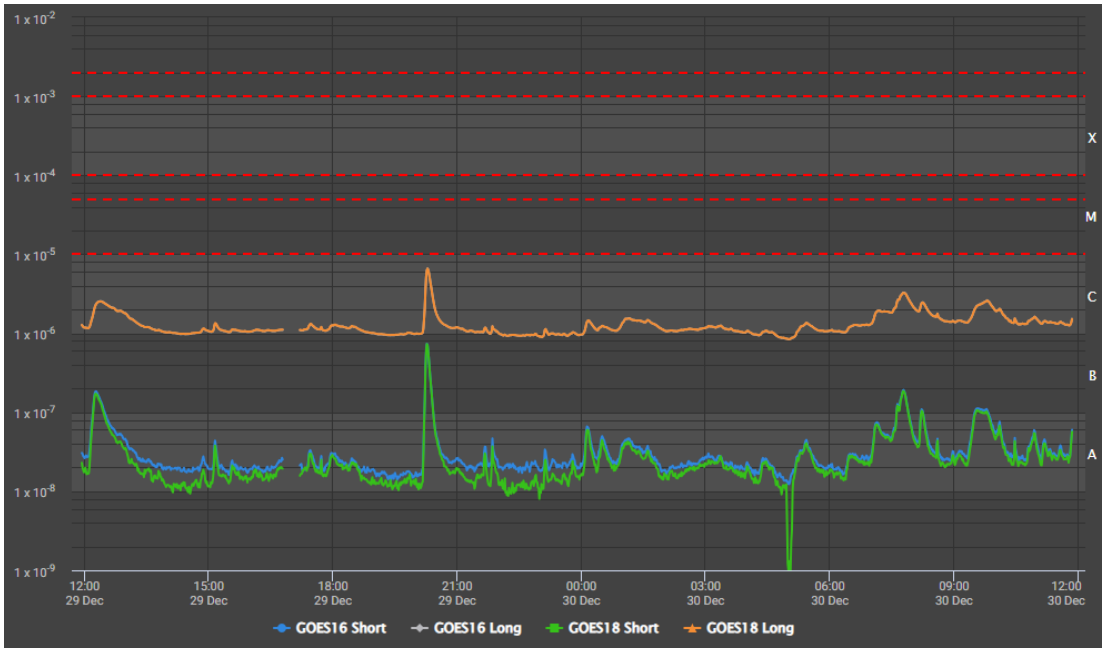
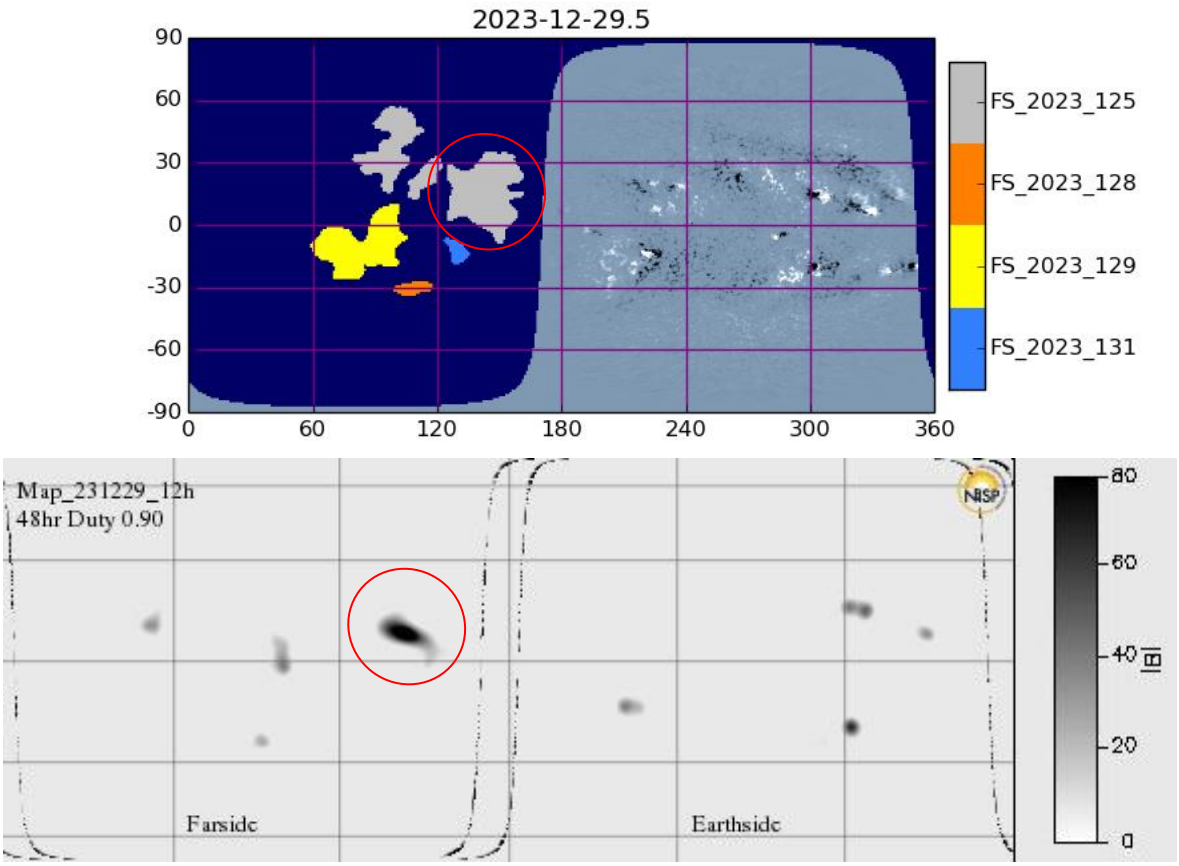


Figure 3b: Far-side products (Stanford.edu and NISP H-alpha) showing notable region over E limb (circled).



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Solar Radiation Storms - (High Energy Protons):

GOES16 high energy (greater than 10MeV) proton flux is currently at background persist at this level. There remains a slight chance of minor increases, given any notable flares from the sunspots in the western hemisphere or just over the western limb, or from any notable filament eruptions.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) has seen diurnal fluctuations between background and moderate. Flux is likely to drop out to mainly background with the onset of the fast wind of CH86, before increasing to Moderate day 4 (02 Jan) with a slight chance of peaking at High.

Electron fluence is expected to show a steady trend, remaining well below the Active (1e8 integrated pfu) threshold, but likely showing an increasing trend on day 4 (02 Jan) as a result of the resent fast wind onset. This is in line with REFM which is currently giving good guidance.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	1
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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